ECMWF COPERNICUS NOTE

Copernicus Atmosphere Monitoring Service

Proposal for the inclusion of a bias correction in the CAMS Radiation Service

Proposed by Armines to Transvalor

Issued by: Armines / Lucien Wald

Date: 10/07/2017

Ref:

CAMS72_2015SC2_note_201707_acceptance_bias_correction_v1

IMPLEMENTED BY ECMWF

1 Description of the update reason

As a whole, the CAMS Radiation Service exhibits satisfactory results as a fast implementation of radiative transfer theory for the direct, diffuse and global irradiance for clear and cloudy skies when compared to qualified in situ measurements.

The numerous quarterly validation reports as well as several publications: Qu et al. (2016, 15 min) and Thomas et al. (2016, 1 h) for BSRN sites, Thomas et al. (2016) for Brazil (1 h, global) and Marchand et al. (2016) for Oman and UAE (1 h, global), have shown that the correlation coefficients between the ground measurements and the estimates are great. It is proven that that the CAMS Radiation Service offers accurate estimates of changes in time of the SSI every 15 min.

The correlation coefficients for Copernicus Radiation Service are very similar to those reached by the commercial services HelioClim-3v4 and v5. It may be concluded that Copernicus Radiation Service has reached a high degree of maturity regarding the ability to reproduce the changes in time of the SSI at various summarizations, from 15 min up to 1 day and more.

The relative bias of global irradiance is often positive and large, noting an overestimation by CAMS Radiation Service: 0 % to 12 % for BSRN data sets (Qu et al., 2016; Thomas et al., 2016), 2 to 16 % for Brazil (Thomas et al., 2016). The situation for Oman and UEA is different as there the bias is small: 5 % to 0 %; this may be explained by the parallax effect because this area is on the very edge of the Meteosat field of view (Marchand et al., 2016). On the contrary, the retrieval of the direct usually exhibits an underestimation.

The inclusion of several stations measuring the solar irradiance in various climates in the quarterly validation reports has confirmed a usual overestimation of the global and an underestimation of the direct from the CAMS Radiation Service. These drawbacks have been reported and underlined by users of CAMS Radiation Service. The quality of the retrievals depends on the site and especially of its climate. Efforts must be done to reduce this bias and as soon as possible in order to keep companies as users.

2 Partner providing the update proposal and staff

Armines.
Philippe Blanc, with Benoît Gschwind and Lucien Wald

3 Description of the update

The update consists in performing an on-the-fly post-processing of the original values delivered by the CAMS Radiation Service (CRS) in order to correct them before the delivery to the user.

The post-processing consists in two abaci, one for the global irradiance and one for the direct irradiance. Given an original time-series of outputs from the CRS, one computes the corresponding time-series of clearness index, direct clearness index and solar zenithal angle. These three quantities

are the entries of the abaci, which in turn provide two quantities that are added to respectively the clearness index and direct clearness index. These indices are converted into corrected irradiances. These corrected irradiances are added into the original times-series. The corrected time-series are eventually delivered to the user.

4 Description of the principle and initial results

The principle of the bias correction is as follows:

- compute the bias at several locations where high quality measurements of irradiance are available. The greater the number of these locations, the better;
- find known quantities that explain the bias and develop a model.

Measurements of direct, diffuse and global irradiance performed every 1 min were collected at fourteen BSRN stations for periods running from 2004-02 to 2015-12 depending on the sites. The measurements were aggregated every 15 min.

Differences were calculated as CRS data minus ground measurements. Several tests were performed to find out what are the best known quantities that may explain the differences in a statistical sense. The number of the quantities must be small for the correction to remain tractable.

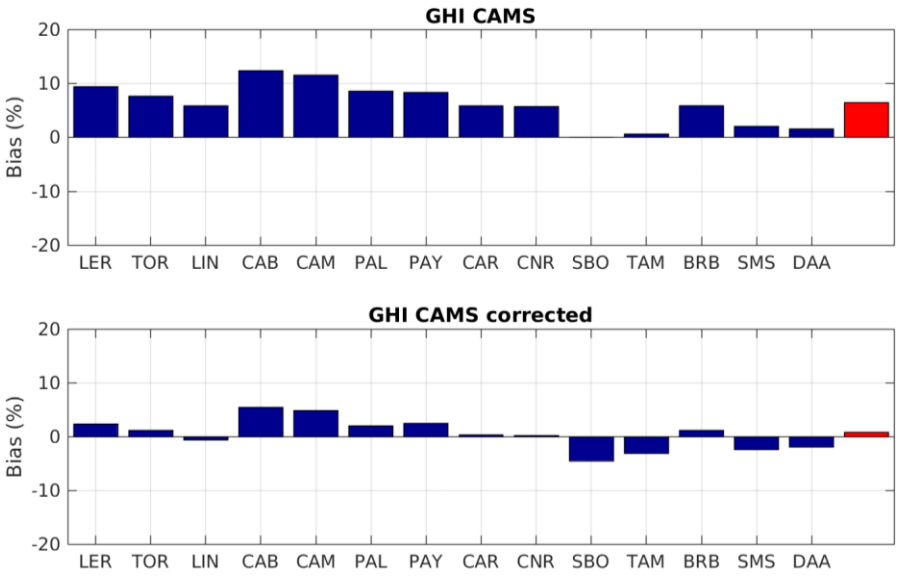
It was found that it is more efficient to correct the clearness index (global and direct) than the irradiance itself. Then the corrected irradiance is computed from the corrected clearness index. Better results were attained by considering an additive correction to clearness index instead of a multiplying coefficient or more complex function. A non-parametric regression was applied with clearness index and solar elevation angle as inputs.

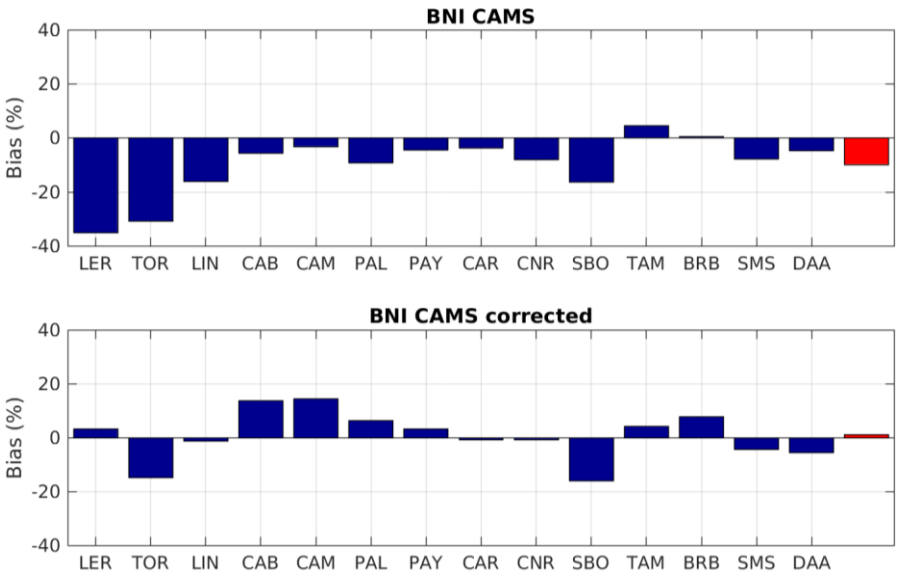
For a given couple (solar elevation angle, clearness index), the correction is approximately the mean of the differences found for this couple. A difficulty encountered in the study is that not all couples are represented in the data sets used to in the study. A mathematical technique called kernel density estimation was employed to fill the gaps and to obtain a dense and complete correction table.

The table was created by using half of the data randomly selected and was tested on the other half. This procedure was repeated several times by excluding one station at each time and comparing the results obtained for this station to its measurements.

The following graphs show the relative bias for each station before and after correction for the global and direct irradiances. The bias when merging all data is shown in red. Improvements are brought by the correction as a whole for the global irradiance. It could be noted that the bias is increased in absolute value for Sede Boqer and Tamanrasset. Otherwise it remains unchanged and in most of the cases, it has decreased in absolute value. Improvements are also observed for the direct irradiance though the situation is more complex. For example, there is degradation in bias at Camborne, Cabauw and Brasilia.

As a whole, the correction brings a benefit and should be implemented. Note that these results were obtained with McClear v2. Because the correction is empirical, it should be recalculated once McClear v3 in operation.





5 Specific tests performed

The development of the abaci was performed using ground measurements performed in the BSRN network. The validation of the benefits of bring this correction was performed using other measurements made at the same stations.

The validation data as well as the results of the validation have been made available to Transvalor. The validation protocol and the associated tools are shared with Transvalor prior to the inception of CAMS.

6 Results obtained

Results have been made available for each station in the form of Matlab matrices as well as graphs and tables.

7 References

Marchand, M., Al-Azri, N., Ombe-Ndeffotsing, A., Wey, E., , Wald, L.: Evaluating meso-scale change in performance of several databases of hourly surface irradiation in South-eastern Arabic Peninsula. Advances in Science and Research, 14, 7-15, doi:10.5194/asr-14-7-2017, 2017.

Qu, Z., Oumbe, A., Blanc, P., Espinar, B., Gesell, G., Gschwind, B., Klüser, L., Lefèvre, M., Saboret, L., Schroedter-Homscheidt, M., and Wald L.: Fast radiative transfer parameterisation for assessing the surface solar irradiance: The Heliosat-4 method, Meteorologische Zeitschrift, 26, 33-57, doi:10.1127/metz/2016/0781, 2017.

Thomas, C., Wey, E., Blanc, P., and Wald, L.: Validation of three satellite-derived databases of surface solar radiation using measurements performed at 42 stations in Brazil. Advances in Science and Research, 13, 81-86, 2016, doi:10.5194/asr-13-81-2016.

Thomas, C., Wey, E., Blanc, P., Wald, L., and Lefèvre, M.: Validation of HelioClim-3 version 4, HelioClim-3 version 5 and MACC-RAD using 14 BSRN stations. SHC 2015, Istanbul, Turkey, 2-4 December 2015. Energy Procedia, 91, 1059-1069, 2016.

Copernicus Atmosphere Monitoring Service

ECMWF - Shinfield Park, Reading RG2 9AX, UK

Contact: info@copernicus-atmosphere.eu